REMARKS

The Official Action of September 9, 2004 has been carefully considered and reconsideration of the application as amended is respectfully requested.

Claim 27 has been amended while Claims 33 to 41 have been cancelled. Claims 24 to 32 are thus presently in the application.

With the cancellation of Claims 33 to 41, the bases for the objection at the top of page 2 of the Official Action and the rejections of claims 33-36 at pages 6-7 of the Official Action have been removed. The only other rejection of record is a rejection of Claims 24 to 32 on the basis of obviousness, in the light of US 4886651 (Patel et al) in view of US 2494561 (Kemp). Applicants respectfully traverse this rejection.

As set out in the "Background of the Invention" on pages 1 to 4 of the present specification, numerous practical problems are experienced in marrying ammonia synthesis with hydrocarbon synthesis processes, and in running ammonia synthesis / hydrocarbon synthesis integrated plants. For example, the Fischer-Tropsch process requires a synthesis gas that contains H_2 and CO in a ratio at, or below, about 2.5:1, preferably at or below 2.0:1 - see page 3 lines 1 to 3. In contrast, ammonia synthesis requires a very high H_2:CO ratio. As also indicated on pages 3 and 4 of the specification, the Applicant is aware of only one known installation for a combined ammonia synthesis / Fischer-Tropsch process. While this process can cater for

synthesis gas having a high H_2:CO ratio to the Fischer-Tropsch reactor, it is not suitable when it is desired to produce primarily liquid fuels from the Fischer-Tropsch process. There thus remains a need to overcome this problem. Still further, there is a need for optimizing conversion of natural gas to synthesis gas so that desired H_2:CO ratios are obtained for use in both the production of hydrocarbons and the production of ammonia - see page 4 lines 16 to 18.

Dealing firstly with Patel (US 4886651), this patent describes an integrated process for producing higher alcohols (C_2 - C_6), methanol and ammonia in which two parallel reformations of methane are used to produce two synthesis gases. Features of this process include:

(1) A first reforming train which is run so as to produce synthesis gas having a high H_2:CO ratio. H_2 is removed from this synthesis gas for use in an ammonia synthesis step, while the hydrogen-poor syngas is sent to a higher alcohol synthesis step;

(2) The hydrogen-poor synthesis gas is mixed with synthesis gas from a second reforming train, and used for higher alcohol synthesis; and

(3) CO_2 is removed from the synthesis gas prior to it being fed to the alcohol synthesis. The pure CO_2 streams from each reformer are recycled to the feed to the reformers.

However, US 4886651 does not at all teach or suggest an important feature of Claim 24, namely the use of the same combined reforming section by both the

hydrocarbon synthesis process and the ammonia synthesis process, ie a separate reforming section for the hydrocarbon synthesis process on the one hand and a separate reforming section for the ammonia synthesis process/plant on the other hand, are not required for the present invention. As indicated above, and as is clearly evident from the figure of US 4886651, it teaches the use of two essentially separate reforming trains. Thus, broadly, in the one reforming train of US 4886651, a reformer 12 is used to produce hydrogen which is used for ammonia synthesis, while another reforming train provided by the primary reformer 32 and the secondary reformer 34 is used to generate synthesis gas for higher alcohol synthesis.

Although it may appear that the problem of marrying the conflicting H_2:CO ratio requirements in synthesis gas for Fischer-Tropsch or higher alcohol synthesis (low H_2:CO ratio) on the one hand and that for ammonia production (high H_2:CO ratio) on the other hand is, in the case of the present invention and US 4886651, solved in similar manner, (ie preparing a synthesis gas that is too rich in H_2 for Fischer-Tropsch or high alcohol synthesis, extracting H_2 from this stream to yield a synthesis gas with a composition suitable for Fischer-Tropsch or higher alcohol synthesis, and feeding the extracted H_2 to ammonia synthesis), this is not the case. US 4886651 teaches that two parallel reformer trains, as broadly identified above, are required to achieve this. In contrast, the Applicant has surprisingly found that it is possible to achieve this by using a single reforming train or section.

Thus, dealing more specifically with US 4886651, its first reforming train

(reformer 12) uses reforming in the presence of stream and CO_2 to produce a synthesis gas that has a too high H_2:CO ratio for higher alcohol production. CO_2 is removed from this stream and returned to the reforming step. Removal and recycling of CO_2 is effected to lower the H_2:CO ratio and to improve the overall carbon utilization of the process. H_2 is extracted from the CO_2 depleted stream to yield a synthesis gas with the correct H_2:CO ratio for higher alcohol synthesis, with the extracted H_2 being sent to an ammonia synthesis stage. The second reforming train utilizes a series combination of steam reforming in the presence of CO_2 followed by oxygen fed reforming to yield a synthesis gas with a H_2:CO ratio suitable for higher alcohol synthesis. Once again, CO_2 is removed from the synthesis gas and recycled to the reforming step in order to lower the H_2:CO ratio and to improve the overall carbon utilization of the process. The two synthesis gas streams produced in this fashion are then combined and fed to a higher alcohol synthesis stage.

The process of US 4886651 suffers from the following disadvantages:

(1) Two separate reforming trains are required. Compared to a process of similar capacity having a single reforming train, the benefits associated with economies of scale for a single reforming train resulting in less expensive synthesis gas generation, are therefore not realized; and

(2) Only two mechanisms exist for adjusting the H_2:CO ratio of the synthesis gas produced in the second reforming train, namely

(a) extracting more H_2 from the synthesis gas produced by the first reforming train than required to achieve the desired H_2:CO ratio, so that on mixing of the synthesis gas streams from the two reforming trains, a combined stream with a suitable H_2:CO ratio is achieved; and

(b) removal and recycle of CO_2 as described above. Removal of CO_2 from the entire synthesis gas production of the second reforming train is expensive. In order to achieve the desired low H_2:CO ratio, a large CO_2 recycle may be required. US 4886651 specifically teaches that the stream exiting the oxygen fed reformer has a CO_2 content of 17%. Such a recycle clearly adds substantially to the required size of reforming equipment and also introduces an additional compression duty.

In contrast, as indicated above, the presently claimed invention uses a single combined reforming train. In this manner, benefits associated with economies of scale are achieved. The synthesis gas produced by this single reforming train is too rich in H_2. The desired H_2:CO ratio is now achieved by extracting H_2 from this stream, with the extracted H_2 being fed to the ammonia synthesis plant.

The presently claimed invention therefore does not have, as an absolute or essential requirement, the use of excessive recycle of CO_2 to achieve a desired low H_2:CO ratio, as is the case for the second reforming train in US 4886651. However, as an optional feature in the present invention, removal of CO_2 may be effected from streams downstream of the reforming section, but this is thus not an absolute requirement as is the case in US 4886651. For example, in one embodiment of the invention, as envisaged in Claim 30, it teaches removal of CO_2 from a portion of the synthesis gas stream only, rather than from the total synthesis gas production, as described in US 4886651.

US 4886651 also cites an additional benefit for the removal of CO_2 from the synthesis gas, and recycle of this removed CO_2 to the reforming stages, namely the improved overall carbon utilization of the process. In the present case, a similar goal can be achieved by recycling Fischer-Tropsch tail gas to the reforming section, as claimed in Claim 32. This clearly does not involve any expensive CO2 separation step. The recycle stream comprises mainly CO_2, as the H_2 and CO have reacted to form hydrocarbon products.

Turning now to US 2494561 (Kemp), this patent teaches an integrated process for producing liquid hydrocarbons and oxygenated hydrocarbons along with ammonia.

A single air separation unit is used to produce oxygen for reforming and

nitrogen for ammonia synthesis (figure).

A single oxygen only fed reforming section is used to produce synthesis gas with a low H_2:CO ratio of around 2:1 (column 4 lines 47-53). This synthesis gas is split into two streams of the same composition:

(1) The first stream is subjected to water gas shift to increase the H2 content to effectively produce a second synthesis gas stream with a high H_2:CO ratio (figure). This stream is now worked up to hydrogen of a suitable quality to serve as feed to ammonia synthesis by condensing excess water, removing CO_2 and CO and further purification steps (column 6 lines 48 to 56); and

(2) The second stream is used directly to synthesise hydrocarbons from H_2 and CO (figure).

The problems associated with marrying an ammonia synthesis process with a hydrocarbon synthesis process, as hereinbefore discussed, is addressed, in US 2494561, by effectively producing two synthesis gas streams (column 4 lines 53 to 61):

(1) The portion of the synthesis gas stream from the reforming section that is subjected to the water gas shift yields a synthesis gas stream with a high H_2:CO ratio that, in accordance with conventional wisdom, is suitable for ammonia synthesis; and

(2) The remaining portion of the synthesis gas stream from the reforming section has a low H_2:CO ratio that, in accordance with conventional wisdom, is suitable for producing liquid hydrocarbons.

In contrast, the solution adopted in the presently claimed invention is to produce a single synthesis gas stream with a too high H_2:CO ratio using a single reforming section, extracting H_2 from this stream to yield a stream with a H_2:CO ratio suitable for hydrocarbon synthesis and combining the extracted H_2 with N_2 from the air separation unit to form the feed to ammonia synthesis.

The feature of US 2494561 concerning the same catalyst being used for ammonia synthesis and hydrocarbon synthesis, is not relevant to the present invention. No mention is made of this feature in the specification. Rather, the invention allows for a conventional optimised iron catalyst to be used for ammonia synthesis (p. 1 line 17) and an optimised selective catalyst, typically iron or cobalt, to be used for hydrocarbon synthesis (p. 2 line 18-19).

Thus, to summarize, the problem solved by the presently claimed invention is using a single reforming section that produces a single synthesis gas that is suitable for both ammonia synthesis and hydrocarbon synthesis. In contrast, US 2494561 effectively produces two synthesis gas streams. The first has a high H_2:CO ratio and is, in accordance with conventional wisdom, suitable for ammonia synthesis. The second has a low H_2:CO ratio and is, in accordance with conventional wisdom,

suitable for hydrocarbon synthesis.

On the other hand, US 4886651, similarly to the presently claimed invention, prepares a synthesis gas that is too rich in H_2 for Fischer-Tropsch or higher alcohol synthesis, extracts H_2 from this stream to yield a synthesis gas with a composition suitable for Fischer-Tropsch or higher alcohol synthesis, and feeds the extracted H_2 to ammonia synthesis. However, US 4886651 teaches that two parallel reformer trains producing two synthesis gas streams are required to achieve an integrated process. This also necessitates the recovery and recycling of CO_2 to achieve the desired H_2:CO ratio in the synthesis gas produced by the second reforming section.

It is therefore respectfully submitted that the prior art, neither singly nor in combination, suggests an integrated process for producing ammonia and hydrocarbons in which a single reforming train is used to produce a single synthesis gas stream that is suitable for both ammonia synthesis and Fischer-Tropsch synthesis as claimed in the present invention.

In view of the above, it is respectfully submitted that all rejections and objections of record have been overcome and that the application is now in allowable form. An early notice of allowance is earnestly solicited and is believed to be fully warranted.

Respectfully submitted,

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